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TOXICITY OF CERTAIN ORGANIC INSECTICIDES TO CODLING MOTH LARVAE IN LABORATORY TESTS

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INTRODUCTION

In view of the importance of insecticides to the fruit industry, laboratory investigations of the toxicity of compounds to the codling moth (*Carpocapsa pomonella* (L.)) have been continued. And it has seemed fitting to keep primarily within the field of organic compounds because of the relatively small percentage of these compounds that have been studied in this connection.

METHODS

The toxicological results given in this circular were obtained for the most part from 1934 to 1936, inclusive, at the Agricultural Research Center, Beltsville, Md. All tests were made by means of the apple-plug method.[1] In explanation of the tables, it should be stated that the number of spray applications refers to the number of times the apple plugs on an endless belt passed beneath the spray nozzle. When two applications of spray material were made, the first spray deposit was allowed to dry before the second was applied. Except where otherwise noted in the tables, each compound was used at the rate of 4 pounds to 100 gallons of the carrier.

In the investigations of these organic compounds it was found that many of them were difficult to wet and therefore not easy to suspend uniformly in the carrier. In an attempt to improve this condition, wetting agents such as bentonite, alcohol, and other compounds were used in many of the experiments as an addition to the carrier. Although lead arsenate itself is readily suspended in water, wetting agents were added to it in some of the tests for purposes of comparison with the organic compounds similarly wetted.

[1] SIEGLER, E. H., and MUNGER, FRANCIS. A FIELD AND LABORATORY TECHNIQUE FOR TOXICOLOGICAL STUDIES OF THE CODLING MOTH. Jour. Econ. Ent. 26: 438–445, illus. 1933.
——— MUNGER, F., and GAHAN, J. B. IMPROVEMENT IN "APPLE PLUG" TECHNIC FOR TOXICOLOGICAL STUDIES OF THE CODLING MOTH. Jour. Econ. Ent. 27: 1140–1142, illus. 1934.

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RESULTS OF TESTS

In the evaluation of the toxicity of compounds to the newly hatched codling moth larva, the experience of the authors indicates that close reproducibility in results is not usually obtained, even with a compound as uniform as lead arsenate. Many factors contribute to this variability and, unfortunately, some of the more important ones are beyond the control of the investigator. The results given in this circular therefore represent only a rough estimate of the toxicity of the various organic compounds reported. A more accurate evaluation could be obtained only through much more extensive testing.

Only a comparatively small number of the organic compounds included in this study have exhibited any marked toxicity to the codling moth larva. This is evident from a comparison of the results with these and with those obtained with unsprayed plugs and plugs sprayed with lead arsenate as given in tables 1 and 2, respectively.

In table 2, in which the toxicological results with lead arsenate are given, it will be noted that a lowering of the surface tension of the carrier, as with the addition of a very large proportion of ethyl alcohol or casein ammonia, led to a reduction in its effectiveness. It should be appreciated, however, that this does not necessarily follow when these or other wetting agents are necessary to obtain a more uniform suspension of organic compounds than could be gotten with water alone.

With the exception of those tests of lead arsenate in which its effectiveness was apparently lowered by the presence of too much wetting material, this compound generally held the percentage of wormy apple plugs to less than 50.

The results of the tests of organic compounds will be found in table 3.

It will be noted that the compounds listed in this table have been arranged in groups. This classification is purely an arbitrary one, as it is obvious that some of the materials could be placed in any one of several groups. This classification has been used, however, in reporting tests of synthetic organic compounds against other insects and, for convenience, is used in this work. When sufficient data with regard to a particular insect have been assembled, it might be advisable to reclassify certain compounds to show the relationship between chemical constitution and toxicity.

The "standard error of percent wormy" was calculated from a generalized standard deviation derived from analyses of variance based on survivals in groups of 0 to 10.0, 10.1 to 20, and 90.1 to 100. By this method occasional values of 0 and 100 percent are shown with standard errors, indicating the probability that the result is not exactly reproducible and that in longer series values greater than 0 or less than 100 percent would frequently be encountered. Wherever the standard error has not been recorded, the test was not examined in such manner as would permit of statistical treatment.

The key symbols necessary to an understanding of the data of the tables in this circular are as follows:

Carriers for the insecticide materials

1=Water.
2=Water+bentonite, 2 pounds to 100 gallons.
3=Water+bentonite, 4 pounds to 100 gallons.
4=Water+bentonite, 5 pounds to 100 gallons.
5=Water+glycerin, 4 pounds to 100 gallons.
6=Water+casein ammonia (1-percent solution), 2 pounds to 100 gallons.
7=Water, 80 percent,+acetone, 20 percent.
8=Water, 90 percent,+ethyl alcohol,[3] 10 percent.
9=Water, 90 percent,+acetone, 10 percent+tannic acid, 8 pounds to 100 gallons.
10=Water, 80 percent,+acetone, 20 percent+bentonite, 4 pounds to 100 gallons.
11=Water, 80 percent,+ethyl alcohol,[3] 20 percent+casein ammonia (1-percent solution), 2 pounds to 100 gallons.
12=Water, 80 percent,+ethyl alcohol,[3] 20 percent.
13=Water, 50 percent,+ethyl alcohol,[3] 50 percent.
14=Ethyl alcohol,[3] 90 percent,+carbon tetrachloride, 10 percent.
15=Ethyl alcohol.[3]

Sources of larvae

L=Local, i. e., from Virginia or West Virginia.
A=Arkansas.
W=Washington.

TABLE 1.—*Percentage of infestation of unsprayed apple plugs by codling moth larvae in laboratory tests*

Source of larvae	Apple plugs			Standard error of percent wormy
	Total	Wormy	Stung	
	Number	*Percent*	*Percent*	
L	513	89	1	----------
A	405	84	0	----------
W	795	94	1	±0.8

TABLE 2.—*Results of laboratory tests of lead arsenate against codling moth larvae*

Carrier	Spray applications	Source of larvae	Apple plugs			Standard error of percent wormy
			Total	Wormy	Stung	
	Number		*Number*	*Percent*	*Percent*	
1	1	L	985	25	11	----------
2	1	L	105	18	3	----------
3	1	L	109	43	8	±4.5
1	1	A	205	44	2	----------
3	1	A	99	53	11	----------
3	1	W	190	37	8	----------
1	2	L	47	11	4	±4.5
1	2	A	38	26	16	±6.8
13	2	A	39	46	5	±7.1
12	2	A	31	48	13	±6.4
15	2	A	78	65	5	±5.8
1	2	W	485	46	10	±1.7
5	2	W	91	45	7	±4.5
6	2	W	109	63	3	±4.5

[3] The ethyl alcohol was 95-percent strength.

TABLE 3.—*Results of laboratory tests of various organic compounds used as insecticides against codling moth larvae*

Compounds	Carrier [1]	Spray applications	Source of larvae	Apple plugs			Standard error of percent wormy
				Total	Wormy	Stung	
		Number		*Number*	*Percent*	*Percent*	
AMINES, IMINES, AND AMIDES							
N-Acetyl-1-naphthylamine, $C_{12}H_{11}NO$	1	1	L	95	80	3	
N-Benzal-S-(o-nitrophenyl)-sulphuramine, $C_{13}H_{10}N_2O_2S$	2	1	L	97	76	2	
Benzamide, C_7H_7NO	2	1	A	89	78	1	
p, p′-Dithiocyanodiphenylamine, $C_{14}H_8N_2S_2$	2	1	L	91	63	3	
S-(o-Nitrophenyl)-sulphuramine, $C_6H_6N_2O_2S$	2	1	A	92	79	2	
Thiocarbanilide,[2] $C_{13}H_{12}N_2S$	4	1	A	93	47	1	
Triphenylamine,[2] $C_{18}H_{15}N$	4	1	W	92	59	1	
Acetoacetanilide, $C_{10}H_{11}NO_2$	12	2	A	45	84	0	±5.8
Acetone semicarbazone, $C_4H_9N_3O$	12	2	W	46	46	4	±6.4
N-Acetyl-p-toluidine, $C_9H_{11}NO$	3	1	L	73	79	0	±6.8
Aniline salt of 2,4-dinitrodiphenylamine-6-carboxylic acid, $C_{19}H_{16}N_4O_6$	12	2	W	37	95	0	±3.5
Anthranilic acid, $C_7H_7NO_2$	12	2	A	46	91	2	±3.5
Benzaldehyde semicarbazone, $C_8H_9N_3O$	11	2	W	42	88	3	±5.8
p-Iodoaniline, C_6H_6IN	12	2	W	50	96	2	±3.5
2-Nitro-p-toluidine, $C_7H_8N_2O_2$	1	2	A	50	84	0	±5.8
p-Nitrosodimethylaniline, $C_8H_{10}N_2O$	3	1	L	40	40	0	±7.0
p-Phenylaniline, $C_{12}H_{11}N$	12	2	W	48	98	0	±3.5
Isopropyl allophanate, $C_5H_{10}N_2O_3$	12	2	W	42	74	0	±8.1
4, 4′-Bi(o-thioanisidine), $C_{14}H_{16}N_2S_2$	12	2	A	47	83	0	±5.8
2, 4, 6-Tribromoaniline, $C_6H_4Br_3N$	12	2	W	51	82	2	±5.8
α, α, γ-Triphenylguanidine, $C_{19}H_{17}N_3$	1	1	W	102	61	0	±5.2
α, α′-Dimethylthiopropionamide, $C_5H_{11}NS$	3	1	L	94	94	0	
2, 4-Dinitrophenylhydrazine, $C_6H_6N_4O_4$	12	2	W	46	87	2	±6.5
N, N′-Diphenylethylenediamine, $C_{14}H_{16}N_2$	12	2	W	44	93	2	±3.5
α, γ-Diphenylguanidine, $C_{13}H_{13}N_3$	1	1	L	76	66	1	±5.8
N, N′-Diphenyl-p-phenylenediamine, $C_{18}H_{16}N_2$	12	2	W	45	100	0	±3.5
α, γ-di-o-Tolylguanidine, $C_{15}H_{17}N_3$	1	1	L	77	62	0	±5.8
Ethyl allophanate, $C_4H_8N_2O_3$	12	2	W	48	92	0	±3.5
p-Fluoroaniline, C_6H_6FN	12	2	W	52	90	8	±5.8
Benzidine, $C_{12}H_{12}N_2$	3	1	L	86	93	4	±2.7
o-Chloroaniline, C_6H_6ClN	12	2	W	48	96	4	±3.5
m-Chloroaniline, C_6H_6ClN	12	2	W	49	98	2	±3.5
p-Chloroaniline, C_6H_6ClN	12	2	W	49	98	2	±3.5
2-Chloro-4-nitroaniline, $C_6H_5ClNO_2$	12	2	A	46	72	0	±8.1
4-Chloro-2-nitrodiphenylamine, $C_{12}H_9ClN_2O_2$	12	2	W	33	97	3	±3.9
4-Chloro-o-toluidine, C_7H_8ClN	12	2	W	29	97	3	±3.9
2, 5-Dichloroaniline, $C_6H_5Cl_2N$	12	2	W	34	97	0	±3.5
DYESTUFFS							
Alkali blue	12	2	W	42	92	0	±3.9
Fluorescein	12	2	W	45	89	4	±5.8
Induline	12	2	W	45	60	0	±9.8
Nigrosine	12	2	W	41	76	0	±9.0
Sulfogene brown	4	1	W	91	73	2	
Sulfogene carbon 2B	4	1	W	101	83	0	
Sulfogene golden brown	4	1	W	84	94	2	
Sulfogene yellow	3	1	L	106	82	5	
HYDROCARBONS							
Acenaphthene, $C_{12}H_{10}$	3	1	L	78	89	1	±4.9
Anthracene, $C_{14}H_{10}$	3	1	L	75	81	3	±4.9
Biphenyl, $C_{12}H_{10}$	2	1	L	90	53	0	
p-Cymene, $C_{10}H_{14}$	15	2	A	47	94	0	±3.5
Dimethylnaphthalene, $C_{12}H_{12}$	12	2	A	51	84	0	±5.8
Fluorene, $C_{13}H_{10}$	3	1	L	86	78	12	±6.0
Phenanthrene, $C_{14}H_{10}$	3	1	L	52	75	2	±5.7
1, 3, 5-Triphenylbenzene, $C_{24}H_{18}$	8	1	A	50	93	0	±3.5
β-Truxene	12	2	W	36	86	8	±6.5

[1] Dilution 4 pounds to 100 gallons unless otherwise noted.
[2] Dilution 5 pounds to 100 gallons.

TABLE 3.—*Results of laboratory tests of various organic compounds used as insecticides against codling moth larvae*—Continued

Compounds	Carrier	Spray applications	Source of larvae	Apple plugs			Standard error of percent wormy
				Total	Wormy	Stung	
		Number		*Number*	*Percent*	*Percent*	
HETEROCYCLIC COMPOUNDS WITH SULPHUR IN 5-MEMBERED RING							
1-Anilinobenzothiazole,[1] $C_{13}H_{10}N_2S$	4	1	W	89	85	0	
Benzal - 4 - methyl - 2 (1) thionaphthenone, $C_{16}H_{12}OS$	2	1	A	92	83	1	
1 - Fural - 4 - methyl - 2 (1) thionaphthenone, $C_{14}H_{10}O_2S$	2	1	A	95	80	2	
(Anilinomethyl) - 1 - benzothiazolyl sulphide, $C_{14}H_{12}N_2S_2$	3	1	L	104	94	3	
1 - (Benzoylmercapto)benzothiazole, $C_{14}H_9NOS_2$	1	1	L	67	70	5	±6.2
bis-(1-Benzothiazolyl) disulphide, $C_{14}H_8N_2S_4$	1	1	W	86	85	4	±4.3
bis-(1-Benzothiazolyl) phthalyl disulphide, $C_{22}H_{12}N_2O_2S_4$	1	1	W	52	79	4	±8.1
1-Benzothiazolyl-(p-toluinomethyl) sulphide, $C_{15}H_{14}N_2S_2$	3	1	L	104	79	0	±5.7
1-Benzothiazolyl-(o-toluinomethyl) sulphide, $C_{15}H_{14}N_2S_2$	3	1	L	96	75	2	±5.7
Dibenzothiophene, $C_{12}H_8S$	3	1	L	106	26	31	±4.8
1-Mercaptobenzothiazole, C_7H_5NS	3	1	L	106	81	3	±4.1
4-Methyl-2-keto-pyranothionaphthene $C_{12}H_8O_2S$	3	1	L	98	86	0	±4.1
4-Methyl-2-(1)-thionaphthenone, C_9H_8OS	1	1	L	45	87	0	±6.5
HETEROCYCLIC COMPOUNDS WITH SULPHUR IN 6-MEMBERED RING							
γ, γ'-Dibenzophenothioxin, $C_{20}H_{12}OS$	2	1	L	83	55	0	
Dithiocyanophenothiazine,[2] $C_{14}H_7N_3S_3$	4	1	A	48	67	10	
Thianthrene, $C_{12}H_8S_2$	3	1	A	82	59	4	
Thioxanthydrol, $C_{13}H_{10}OS$	2	1	L	100	34	4	
Thioxanthone, $C_{13}H_8OS$	2	1	L	91	41	7	
Phenothioxin, $C_{12}H_8OS$	7	2	A	51	43	26	±6.4
Phenothioxin, $C_{12}H_8OS$	14	2	A	40	60	20	±8.8
Phenothioxin,[3] $C_{12}H_8OS$	4	1	A	72	6	22	
Phenothioxin, $C_{12}H_8OS$	3	1	A	215	5	22	
Phenothioxin, $C_{12}H_8OS$; infested shortly after application	3	1	A	99	9	24	
Phenothioxin, $C_{12}H_8OS$; infested 4 days after application	3	1	A	93	58	6	
6-Acetylphenothiazine, $C_{14}H_{11}NOS$	12	2	W	53	87	0	±5.8
Phenothiazine-S-oxide, $C_{12}H_9NOS$	12	2	W	47	96	0	±3.9
Phenothiazone, $C_{12}H_7NOS$	12	2	W	48	94	4	±3.9
Thioxanthene, $C_{13}H_{10}S$	3	1	L	97	78	0	±5.4
HETEROCYCLIC COMPOUNDS WITH SULPHUR OUTSIDE THE RING							
N-Fural-S(o-nitrophenyl)-sulphuramine, $C_{11}H_8N_2O_3S$	2	1	A	100	75	4	
α-Phenyl-b-2-pyridyl thiourea, $C_{12}H_{11}N_3S$	2	1	L	82	52	4	
2-Thiobarbituric acid,[4] $C_4H_4N_2O_2S$	4	1	A	75	69	7	
1-Benzoxazole mercaptan, C_7H_5NOS	12	2	W	37	87	3	±6.5
1-Benzoxazole mercaptan acetate, $C_9H_7NO_2S$	12	2	W	52	96	0	±3.5
Benzyl ester of benzylthioxanthic acid, $C_{15}H_{14}S_2$	15	2	A	36	86	3	±5.8
2-Thiocoumarin, C_9H_6OS	12	2	A	34	0	6	±3.9
2-Thiocoumarin, C_9H_6OS	3	1	L	159	24	2	±3.8
2-Thiocoumarin, C_9H_6OS; whole apple residual test, infested same day as sprayed	1	2	A	87	6	0	±2.7
2-Thiocoumarin, C_9H_6OS; whole apple residual test, infested 7 days after spraying	1	2	A	86	72	1	±5.4
9-Thioxanthone, $C_{13}H_8OS$	1	1	L	92	91	0	±2.5
HETEROCYCLIC COMPOUNDS NOT CONTAINING SULPHUR							
Coumarin, $C_9H_6O_2$	2	1	A	92	73	0	
Di-2-pyridylamine, $C_{10}H_9N_3$	2	1	L	100	53	3	
Kojic acid, $C_6H_6O_4$ [2]	4	1	W	94	88	2	
Phthalimide,[3] $C_8H_5NO_2$	4	1	A	91	63	0	

TABLE 3.—*Results of laboratory tests of various organic compounds used as insecticides against codling moth larvae*—Continued

SULPHIDES, DISULPHIDES, SULPHOXIDES, AND MERCAPTANS

Compounds	Carrier	Spray applications	Source of larvae	Apple plugs			Standard error of percent wormy
				Total	Wormy	Stung	
		Number		*Number*	*Percent*	*Percent*	
Acetonyl-o-nitrophenyl sulphide, $C_9H_9NO_3S$	2	1	A	79	73	0	----
2,4-Dihydroxy-2'-nitro-diphenyl sulphide, $C_{12}H_9NO_4S$	2	1	A	95	75	1	----
Diphenyl disulphide,[2] $C_{12}H_{10}S_2$	4	1	A	97	40	5	----
(2 - Hydroxy - 1 - naphthyl) - 2 - nitrophenyl sulphide, $C_{16}H_{11}NO_3S$	2	1	A	88	78	5	----
Methylphenylmethylene - bis (mercapto-acetic acid), $C_{12}H_{14}O_4S_2$	2	1	L	90	63	1	----
2-Naphthyl mercaptan, $C_{10}H_8S$	2	1	A	85	72	1	----
N-(o-Nitrophenylmercapto)-p-toluiline, $C_{13}H_{12}N_2O_2S$	2	1	A	104	64	2	----
o-Aminophenyl methyl sulphide, C_7H_9NS	15	2	A	47	98	0	±3.5
Benzyl thioxanthic acid, $C_8H_8S_2$	15	2	A	35	91	0	±3.9
(4 - Chloro - 2 - nitrophenyl - mercapto) - acetic acid, $C_8H_6ClNO_4S$	12	2	W	42	95	0	±3.5
4 - Chloro - 2 - nitrophenyl sulphur bromide, $C_6H_3BrClNO_2S$	12	2	W	51	78	2	±8.1
Diphenyl sulphoxide, $C_{12}H_{10}OS$	3	1	L	96	58	9	±6.3
Ethyl ester of (4-chloro-2-nitrophenylmercapto) acetoacetic acid, $C_{12}H_{12}ClNO_5S$	12	2	W	48	92	0	±3.5
Triphenyl ester of trithio-arsenious acid, $C_{18}H_{15}AsS_3$	3	1	L	107	80	12	±5.7
Tri-p-tolyl ester of trithio-arsenious acid, $C_{21}H_{21}AsS_3$	3	1	L	105	92	2	±2.5

ACIDS, ALCOHOLS, AND ESTERS

Borneol, $C_{10}H_{18}O$	8	2	A	42	88	0	±5.8
N-Butyl oxalate, $C_{10}H_{18}O_4$	12	2	W	43	95	0	±3.9
2-Chloro-3, 5-dinitrobenzoic acid, $C_7H_3ClN_2O_6$	12	2	W	44	59	0	±8.8
Citronellol, $C_{10}H_{20}O$	12	2	W	47	92	6	±3.9
Dihydrocitronellol, $C_{10}H_{20}O$	12	2	W	48	94	0	±3.9
α, p-Dimethyl-benzyl alcohol, $C_9H_{12}O$	12	2	W	31	97	0	±3.9
4, 6-Dinitro-o-cresol acetate, $C_9H_8N_2O_6$	1	1	L	42	10	17	±4.4
Epichlorohydrin, C_3H_5ClO	12	2	W	37	97	0	±3.9
Ethyl oxalate, $C_6H_{10}O_4$	12	2	W	36	100	0	±3.9
Geraniol, $C_{10}H_{18}O$	12	2	W	25	96	4	±3.9
Hydrocinnamic acid, $C_9H_{10}O_2$	12	2	W	51	100	0	±3.5
Linaloöl, $C_{10}H_{18}O$	12	2	W	33	100	0	±3.9
Octaacetyl sucrose, $C_{28}H_{38}O_{19}$	12	2	W	48	92	0	±3.5
α-Isopropyl-α-methyl benzyl alcohol, $C_{11}H_{16}O$	12	2	W	30	100	0	±3.9

ALDEHYDES, KETONES, THIOALDEHYDES, AND THIOKETONES

Acetophenone, C_8H_8O	12	2	A	45	96	2	±3.5
Anthraquinone, $C_{14}H_8O_2$	1	1	L	60	63	5	±6.7
Benzil, $C_{14}H_{10}O_2$	8	2	A	41	81	2	±5.8
Benzoin, $C_{14}H_{12}O_2$	12	2	W	46	100	0	±3.9
α-Bromo-p-phenylacetophenone, $C_{14}H_{11}BrO$	1	1	L	69	88	3	±4.9
p-Chloroacetophenone, C_8H_7ClO	15	2	A	38	97	3	±3.5
2-Chloroanthraquinone, $C_{14}H_7ClO_2$	3	1	L	86	97	1	±2.7
Cyclopentanone, C_5H_8O	12	2	W	37	97	0	±3.9
Desoxybenzoin, $C_{14}H_{12}O$	12	2	W	33	97	0	±3.5
2-Ethyl hexenal, $C_8H_{14}O$	12	2	W	29	97	0	±3.9
α-Hydroxy-p-phenylacetophenone acetate, $C_{16}H_{14}O_3$	1	1	W	54	94	0	±3.5
α-Hydroxy-p-phenylacetophenone chloracetate, $C_{16}H_{13}ClO_3$	1	1	W	53	87	0	±5.8
α-Hydroxy-p-phenylacetophenone formate, $C_{15}H_{12}O_3$	1	1	W	51	96	0	±3.5
Mesityl oxide $C_6H_{10}O$	12	2	W	45	89	4	±6.5
p-Methylacetophenone, $C_9H_{10}O$	12	2	W	39	95	0	±3.9
2-Methylanthraquinone, $C_{15}H_{10}O_2$	3	1	L	106	89	1	±4.1
Trithioformaldehyde,[3] $C_3H_6S_3$	4	1	W	76	51	3	----
Trithiovanillin, $C_{24}H_{24}O_6S_3$	12	2	W	42	86	2	±5.8
Tri-(thiovanillin benzoate), $C_{45}H_{36}O_9S_3$	12	2	W	63	94	2	±3.2

TABLE 3.—*Results of laboratory tests of various organic compounds used as insecticides against codling moth larvae*—Continued

ALKYL AND ARYL HALIDES

Compounds	Carrier	Spray applications	Source of larvae	Apple plugs			Standard error of percent wormy
				Total	Wormy	Stung	
		Number		*Number*	*Percent*	*Percent*	
o-Bromobiphenyl, $C_{12}H_9Br$	11	2	W	23	91	4	±5.5
p-Bromobiphenyl, $C_{12}H_9Br$	12	2	W	44	27	32	±6.8
p-Chlorobiphenyl, $C_{12}H_9Cl$	3	1	L	101	67	4	±5.2
p-Chloroiodobenzene, C_6H_4ClI	12	2	W	41	93	0	±3.5
4, 4'-Dibromobiphenyl, $C_{12}H_8Br_2$	12	2	W	54	100	0	±3.5
4, 4'-Dichlorobiphenyl, $C_{12}H_8Cl_2$	10	1	L	101	66	3	±5.2
4, 4'-Difluorobiphenyl, $C_{12}H_8F_2$	12	2	W	53	100	0	±3.5
p, p'-Diiodobiphenyl, $C_{12}H_8I_2$	12	2	W	43	98	0	±3.9
p-Fluorobrombenzene, C_6H_4BrF	12	2	W	50	100	0	±3.5
o-Fluorochlorbenzene, C_6H_4ClF	12	2	W	45	91	0	±3.5
σ-Fluorochlorobenzene, C_6H_4ClF	12	2	W	47	98	0	±3.5
p-Fluoroiodobenzene, C_6H_4FI	12	2	W	50	100	0	±3.5
Hexachlorobenzene, C_6Cl_6	3	1	L	69	73	0	±6.8
Hexachloroethane, C_2Cl_6	3	1	L	87	66	0	±3.5
o-Iodobiphenyl, $C_{12}H_9I$	12	2	W	41	98	0	±3.5
p-Iodobiphenyl, $C_{12}H_9I$	12	2	W	45	93	2	±3.9
1, 2, 3, 4,-Tetrachloronaphthalene, $C_{10}H_4Cl_4$	12	2	A	37	83	3	±7.4

HETEROCYCLIC COMPOUNDS WITH 5-MEMBERED RING NOT CONTAINING SULPHUR

3-Acetamidocarbazole, $C_{14}H_{12}N_2O$	12	2	W	54	100	0	±3.5
9-Acetylcarbazole, $C_{14}H_{11}NO$	12	2	W	38	76	8	±9.0
1-Anilino-benzoxazole, $C_{13}H_{10}N_2O$	12	2	W	51	100	0	±3.5
9-Benzoylcarbazole, $C_{19}H_{13}NO$	12	2	W	49	82	2	±5.8
9-Benzoyl-3-nitrocarbazole, $C_{19}H_{12}N_2O_3$	12	2	W	38	79	18	±9.0
3-Chlorocarbazole, $C_{12}H_8ClN$	12	2	W	41	95	2	±3.9
p-Chloro-α-furalacetophenone, $C_{13}H_9ClO_2$	10	1	L	104	91	1	±2.5
3-Chloro-7-nitrodibenzofuran, $C_{12}H_6ClNO_3$	1	1	W	61	87	2	±5.8
Difuralcyclopentanone, $C_{15}H_{12}O_3$	12	2	W	50	88	4	±5.8
β, α-Dinapthofuran, $C_{20}H_{12}O$	3	1	L	79	90	5	±4.1
α-Furalacetophenone, $C_{13}H_{10}O_2$	12	2	A	30	70	7	±8.2
α-Fural-p-methyl acetophenone, $C_{14}H_{12}O_2$	10	1	L	105	79	4	±5.7
3-Methyl-1-phenyl-5-pyrazolone, $C_{10}H_{10}N_2O$	3	1	L	92	85	4	±4.1
3-Nitrocarbazole, $C_{12}H_8N_2O_2$	12	2	W	51	92	2	±3.5
1-(N-phenylacetamido) benzoxazole, $C_{15}H_{12}N_2O_2$	12	2	W	44	98	0	±3.5
2-Phenylbenzoxazole, $C_{13}H_9NO$	12	2	W	50	8	52	±3.9
Phthalic anhydride, $C_8H_4O_3$	1	1	L	61	71	3	±6.4
Pyromucamide, $C_5H_5NO_2$	10	1	L	95	75	2	±5.7

HETEROCYCLIC COMPOUNDS WITH 6-MEMBERED RING NOT CONTAINING SULPHUR

3, 4-Benzocinnoline oxide, $C_{12}H_8N_2O$	3	1	L	97	88	9	±4.1
3, 4-Benzocinnoline $C_{12}H_8N_2$	3	2	W	48	8	71	
Δ9, 9'-Bixanthene, $C_{26}H_{16}O_2$	3	1	L	76	74	0	±5.7
Butyl ester of 2, 3, 5, 6-tetrahydro-4-keto-6, 6-dimethyl-1, -4-pyran-2-carboxylic acid, $C_{12}H_{20}O_4$	12	2	W	48	98	2	±3.9
6-Chloro-1, 4, 2 - benzothiazine - 3 - (4) - one, C_8H_6ClNOS	1	2	A	33	88	0	±5.8
δ, 5-Dimethyl acridan, $C_{15}H_{15}N$	12	2	W	49	71	0	±8.1
Ethyl ester of 5, 6-dihydro-4-keto-6, 6-dimethyl - 1, 4 - pyran - 2 - carboxylic acid, $C_{10}H_{14}O_4$	12	2	W	40	95	0	±3.5
2, 2, 4-Trimethyl- 1, 2-dihydroquinoline, $C_{12}H_{15}N$	12	2	W	45	100	0	±3.9
Xanthene, $C_{13}H_{10}O$	9	1	L	97	83	11	±4.1
Xanthone, $C_{13}H_8O_2$	1	1	L	85	60	24	±6.3
Xanthydrol, $C_{13}H_{10}O_2$	9	1	L	96	88	1	±4.1
bis (9-Xanthyl) ether, $C_{26}H_{18}O_3$	1	1	W	77	88	0	±4.9

TABLE 3.—*Results of laboratory tests of various organic compounds used as insecticides against codling moth larvae*—Continued

NITRO AND NITROSO COMPOUNDS

Compounds	Carrier	Spray applications	Source of larvae	Apple plugs			Standard error of percent wormy
				Total	Wormy	Stung	
		Number		*Number*	*Percent*	*Percent*	
2, 2'-Dinitrobiphenyl, $C_{12}H_8N_2O_4$	8	2	A	49	82	0	±5.8
Dinitronapthalene, $C_{10}H_6N_2O_4$	3	1	L	35	77	3	±10.4
p-Nitrobiphenyl, $C_{12}H_9NO_2$	3	1	L	106	87	5	±4.1
1-Nitroso-2-naphthol, $C_{10}H_7NO_2$	1	1	L	90	42	3	
p-Nitrophenylacetonitrile, $C_8H_6N_2O_2$	12	2	A	52	81	0	±5.8

PHENOLS AND PHENOL DERIVATIVES

N-Acetyl-p-phenetidine, $C_{10}H_{13}NO_2$	3	1	L	79	84	0	±4.9
p-Aminophenol, C_6H_7NO	2	1	A	91	57	0	
1,1'-Bi-2-naphthol, $C_{20}H_{14}O_2$	3	1	L	90	87	0	±4.1
p-Bromphenol, C_6H_5BrO	8	2	A	50	84	0	±5.8
γ-Bromopropylphenyl ether, $C_9H_{11}BrO$	15	2	A	40	90	0	±5.8
o-Cyclohexyl phenol, $C_{12}H_{16}O$	12	2	W	48	96	0	±3.5
Diamylhydroquinone, $C_{16}H_{26}O_2$	1	2	W	52	69	4	±7.3
4,6-Dinitro-o-cresol,[1] $C_7H_6N_2O_5$	4	1	W	94	0	0	
4,6-Dinitroso-resorcinol, $C_6H_4N_2O_4$	1	1	W	89	75	1	±5.7
p-Hydroxybenzophenone, $C_{13}H_{10}O_2$	3	1	L	107	93	2	±2.5
2'-Hydroxy-2,4-dinitrodiphenylamine-6-carboxylic acid, $C_{13}H_9N_3O_7$	3	1	L	98	86	1	±4.1
2-Methyl-4,6-dinitroanisole, $C_8H_8N_2O_5$	10	1	L	97	25	2	±4.8
Methyl-1-naphthyl ether, $C_{11}H_{10}O$	12	2	W	43	95	2	±3.9
Pentachlorophenol, C_6HOCl_5	3	1	L	51	32	4	±5.4
Salol, $C_{13}H_{10}O_2$	1	2	A	41	98	0	±3.5
2,4,6-Tri-iodophenol, $C_6H_3I_3O$	12	2	W	45	96	4	±3.5
2,6-Xylenol, $C_8H_{10}O$	12	2	A	41	90	0	±6.5

THIOCYANO COMPOUNDS

p-Dimethylaminophenyl ester of thiocyanic acid,[1] $C_9H_{10}N_2S$	4	1	W	87	58	1	
p - Phenyl - α - thiocyanoacetophenone, $C_{15}H_{11}NOS$	3	1	L	91	84	1	±4.1
Tetrahydrolinalyl ester of thiocyanic acid, $C_{11}H_{21}NS$	15	2	A	39	95	3	±3.9
Thiocyanogen, $(CNS)_2$	1	1	L	38	90	0	±6.5
α-p-tolyl-ethyl ester of thiocyanic acid, $C_{10}H_{11}NS$	12	2	W	48	71	19	±8.1

[1] Dilution 5 pounds to 100 gallons.

DISCUSSION

From an examination of the data presented in table 3 it is evident that most of the compounds tested were ineffective. In some instances, however, this may have been due to the fact that the physical manner or condition in which they were used was not the best possible.

Only 17 compounds gave 50 percent or less of wormy apple plugs. These are as follows: Thiocarbanilide, 47 percent; acetone semicarbazone, 46 percent; p-nitroso-dimethylaniline, 40 percent; dibenzothiophene, 26 percent; thioxanthydrol, 34 percent; thioxanthone, 41 percent; phenothioxin, in four tests, in which different kinds or quantities of the same carrier were used, gave 43, 9, 6, and 5 percent; 2-thiocoumarin, in three tests, in each of which a different carrier was used, the percentage wormy was 0, 24, and 6; diphenyl disulphide, 40 percent; 4,6 dinitro-o-cresol acetate, 10 percent; p-bromobiphenyl, 27 percent; 2-phenyl-benzoxazole, 8 percent; 1-nitroso-2-naphthol, 42 percent; 3,5-dinitro-o-cresol, 0 percent; 2-methyl-4-6-dinitroanisole, 25 percent; pentachlorophenol, 32 percent; and 3,4-benzocinnoline, 8 percent.

Attention is called to the fact that the foregoing results apply only to the toxicity of the compounds shortly after their application as sprays. According to these data phenothioxin and thiocoumarin are apparently promising insecticides for the codling moth. The writers wish to point out in this connection, however, that residual tests, in which the apple plugs (kept under laboratory conditions) were infested several days after the application of these compounds, indicated a considerable loss in effectiveness. Perhaps these losses could be overcome if the compounds were applied to the fruit under conditions different from those used in the experiments.

The attention of the reader is also called to the fact that certain compounds have admitted a relatively small percentage of worms, but at the same time have allowed a high percentage of stung fruit. 2-Phenyl-benzoxazole, for example, has given 8 percent of wormy and 52 percent of stung fruit. Since conditions in the field are generally more unfavorable to the spray material than are conditions in the laboratory, the possible value of a given compound should not be based solely on the percentage of wormy plugs as obtained in laboratory tests. Stings made under laboratory conditions may be potential entrances in the field.

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